815 described, compact assemblies can be achieved from which to implement optical functions having many channels or cross-points.

Applicants respectfully request Examiner to substitute a hyphen for the blank between the two words in "fiber optic" in the following locations, in only one instance per paragraph:

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Paragraph [0002] at the second and third lines and before the word "apparatuses";

Paragraph [0003] on the fourth line and before the word "apparatuses";

Paragraph [0010] on the fourth line and before the word "apparatuses";

Paragraph [0013] on fourth line and before the word "technology";

Paragraph [0042] on the fourteenth line and before the word "apparatus";

Paragraph [0043] on the third line and before the word "apparatuses";

Paragraph [0059] on the second line and before the word "couplers".

Amendments To Claims

Cancel claims 1-20 and substitute the following new claims 37-56:

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37. A multiple fiber-optic apparatus comprising:

(a) a first and a second side-polished optical fiber;

(b) a first substrate having a first surface containing at least first and second arcuate grooves that are co-parallel, are spaced apart by a first distance, and hold said first and second side-polished optical fibers respectively, and containing at least a first additional arcuate groove parallel to said first and second arcuate grooves and spaced from them by a second distance;

(c) a third and a fourth side-polished optical fiber;

(d) a second substrate having a second surface containing at least third and fourth arcuate grooves that are co-parallel, are spaced apart by said first distance, and hold said third and fourth side-polished optical fibers respectively, and containing at least a second additional arcuate groove parallel to said third and fourth arcuate grooves and spaced from them by said second distance; and

(e) an alignment fiber;

wherein said first and second surfaces closely face one another with said alignment fiber located within a cavity created by said first and second additional arcuate grooves; and wherein said first and second side-polished optical fibers are oppositely facing said third and fourth side-polished optical fibers to form two 4-port fiber-optic apparatuses;

whereby sliding and rotating said first surface relative to said second surface provides for individually tuning the coupling performance of said two 4-port fiber-optic apparatuses.

38. The multiple fiber-optic apparatus of claim 37, further including a film located at a location selected from one of the group consisting of at least a portion of one of the surfaces, at least portions of each of the surfaces, and at least somewhere between the surfaces.

39. The multiple fiber-optic apparatus of claim 37, further including a material permanently bonding together at least one of the pairs of oppositely facing side-polished optical fibers.

40. The multiple fiber-optic apparatus of claim 37, wherein at least one of the side-polished optical fibers forms part of an apparatus selected from the group including a coupler, an add-drop multiplexer, a tap, a splitter, a joiner, a filter, a modulator or a switch.

41. The multiple fiber-optic apparatus of claim 37, wherein at least two of the side-polished optical fibers are continuous parts of an optical fiber that has never been broken; whereby optical signal degradations are avoided that would otherwise be caused by rejoining individual side-polished optical fibers.

42. The multiple fiber-optic apparatus of claim 37, wherein said first and second arcuate grooves in said first surface of said first substrate are elements in an array of co-parallel grooves, wherein said array of co-parallel grooves contain at least one optical fiber that forms an apparatus selected from one of the group including an optical pass-through, an attenuator, a polarizer, a filter, a modulator, and a switch.

43. The multiple fiber-optic apparatus of claim 37, wherein two or more of the arcuate grooves are at least partially formed along Miller planes of a crystal substrate.

44. The multiple fiber-optic apparatus of claim 43, wherein said crystal substrate is selected from one of the group including silicon, GaAs, lithium-niobate (LiNbO3), potassium dihydrogen phosphate (KDP), lithium tantalate ($LiTaO_3$), barium titanate ($BaTiO_3$), silicon germanium (SiGe), indium phosphide (InP), gallium indium arsinide (GaInAs), a III-V compound, and an organic crystal.

45. A pair of oppositely and intimately facing surfaces of a respective pair of substrates, wherein each of these surfaces contains an array of grooves that are parallel to one another and arcuate in depth, wherein these two arrays are positioned opposite to one another forming an array of channels at least two of which each contains an intimately facing pair of side-polished optical fibers and form a 4-port fiber-optic apparatus, and wherein at least one of said channels contains a single alignment fiber.

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46. The pair of oppositely and intimately facing surfaces of a respective pair of substrates as in claim 45, further including at least one additional substrate surface having an additional alignment groove.

47. The pair of oppositely and intimately facing surfaces of a respective pair of substrates as in claim 46, further including an additional alignment fiber located within said additional alignment groove;
whereby a stack of substrates can be formed and mutually aligned.

48. The pair of oppositely and intimately facing surfaces of a respective pair of substrates as in claim 47, further including an array of grooves on said additional substrate surface;
whereby a stack of arrays of fiber-optic apparatuses can be formed and mutually aligned.

49. The pair of oppositely and intimately facing surfaces of a respective pair of substrates as in claim 45, wherein at least two of the side-polished optical fibers remain parts of a continuous single fiber that has never been broken;

whereby optical signal degradations are avoided that would otherwise be caused by rejoining individual side-polished optical fibers.

50. The pair of oppositely and intimately facing surfaces of a respective pair of substrates as in claim 45, further including a material permanently bonding together at least one of said intimately facing pair of side-polished optical fibers that form a 4-port fiber-optic apparatus.

51. A 4-port fiber-optic apparatus comprising:

(a) a first side-polished optical fiber having a first plane of side polish within a first region of side-polish, having a first longitudinal axis that is arcuate over said first region of side-polish, and having a nearest support region along said first longitudinal axis and to either side of said first region of side-polish;

(b) a second side-polished optical fiber having a second plane of side polish within a second region of side-polish, having a second longitudinal axis that is arcuate over said second region of side-polish, and having a nearest support region along said first longitudinal axis and to either side of said second region of side-polish;

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(c) a thin film of bonding material;

(d) a bonded region; and

(e) a rigid support element secured to said 4-port fiber-optic apparatus at said nearest support regions;

wherein said first and second side-polished optical fibers are permanently bonded together between said first and second regions of side-polish by said thin film of bonding material to form said bonded region;

wherein said bonded region is spaced apart from at least one of said nearest support regions;

whereby at least some thermal stresses from said rigid support element to said regions of side-polish are reduced compared with direct rigid support to said bonded region.

52) The 4-port fiber-optic apparatus of claim 51 further including:

(a) additional such 4-port fiber-optic apparatuses supported in like manner and in common by said support element, wherein all of their respective planes of side-polish are generally coincident to a shared plane of side-polish;

(b) an offset displacement and rotation between each pair of side-polished regions comprising one of the 4-port fiber-optic apparatuses, wherein said offset distance is measured in said shared plane of side-polish;

wherein all of said 4-port fiber-optic apparatuses are members of an array whose individual coupling ratios are determined by their offsets; and

wherein the offsets across the array are correlatable to a combination of a single translation within said shared plane of side-polish and a single rotation about the normal to said shared plane of side-polish.

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53. A 2-port fiber-optic apparatus comprising:

(a) a side-polished optical fiber having a plane of side polish within a region of side-polish, having a longitudinal axis that is arcuate over said region of side-polish, and having a nearest support region along said longitudinal axis and to either side of said region of side-polish;

(b) a rigid support element secured to said 2-port fiber-optic apparatus at the nearest support regions;

wherein said region of side-polish is spaced apart from at least one of the nearest support regions;

whereby at least some thermal stresses from said rigid support element to said region of side-polish is reduced compared with direct rigid support to said region of side-polish.

54. A method of tuning optical coupling within each of multiple 4-port, side polished, fiber-optic apparatuses, the method comprising:

(a) providing two substrates, wherein each said substrate has a first surface with at least a first and second groove each suitable for holding a fiber, wherein said first surfaces are slidable on one another, and wherein a plane of contact exists between the two said first surfaces;

(b) providing two pairs of optical fibers each fiber of which having a side-polished first area, wherein said side-polished first areas of each said pair of optical fibers are mutually plane-parallel, wherein each said pair of optical fibers is sandwiched between said first surfaces, wherein each said optical fiber lies within only one of

said first grooves, and wherein said side-polished first areas of said pairs of optical fibers are pressed against one another and lie substantially within said plane of contact;

(c) providing at least one alignment groove on each of said first surfaces wherein said alignment grooves are parallel and offset relative to said first grooves such that they together form a channel between said two first surfaces;

(d) providing a third fiber having a lengthwise direction;

(e) positioning said third fiber into said channel, wherein said third fiber constrains substrate sliding to a direction substantially parallel to said lengthwise direction; and

(f) sliding one said side-polished first area against the other by sliding said substrates against one another substantially along said lengthwise direction;

whereby said optical coupling within each of multiple 4-port, side polished, fiber-optic apparatuses is easily tuned together.

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55. The method of claim 54 further including:

(a) providing said alignment grooves with a bi-directional taper in said plane of contact to form a region of narrowest channel width and a center of rotation therein;

(b) tuning said optical coupling by slidably rotating said substrates about said center of rotation;

whereby multiple 4-port, side polished, fiber-optic apparatuses can be tuned differently from one another by a combination of translation and rotation.

56. A fiber-optic apparatus comprising:

(a) a first substrate having a first surface with at least one groove suitable for holding a side-polished optical fiber;

(b) a second substrate having a first surface with at least one groove;

(c) at least one side-polished optical fiber having at least one side-polished area sandwiched within and between said grooves of said substrates; and

(d) a material having optical properties and selected from one of the group including a gas, a liquid, a fluid with at least one entrained bubble;

wherein said first surfaces of said substrates are positioned substantially plane-parallel and facing one another;

wherein said side-polished optical fiber is held within said groove suitable for holding a side-polished optical fiber; and

wherein said grooves are aligned substantially opposite to one another forming a channel that extends over said side-polished area and is filled with said material;

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whereby the optical behavior of said side-polished optical fiber is influenced by said material and changes with changes in said optical properties of said material.